

What is claimed is:

1. A recursive discrete Fourier transformation device
wherein data values $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1),$
5 $x(t+N)$ sampled at times $t, t+1, t+2, t+3, \dots, t+N-1, t+N$ (N
is a positive integer which is 1 or more) each having an equal
interval are supplied and as complex Fourier coefficients under
degree k (k is 0 or a positive integer smaller than N) obtained
by, with such N data values supplied since time t as a data
10 stream, carrying out complex Fourier transformation on the
data stream, a real part $X_r(k, t)$ and an imaginary part $X_i(k,$
 $t)$ are obtained, the discrete Fourier transformation device
comprising:

a first temporary storage means for storing the data
15 stream $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1)$ supplied
since time t at time $t+N-1$ temporarily;

a discrete Fourier operation means for obtaining the
complex Fourier coefficients $X_r(k, t)$ and $X_i(k, t)$ of the data
stream stored temporarily in the first storage means; and

20 a second temporary storage means for storing the complex
Fourier coefficients $X_r(k, t)$ and $X_i(k, t)$ obtained by the
discrete Fourier operation means,

the discrete Fourier operation means including:

a subtracting portion for obtaining a data value
25 of a difference between a data value $x(t+N)$ supplied at time
 $t+N$ and a data value $x(t)$ memorized temporarily in the first
storage means;

a constant multiplying portion for obtaining a
signal with a predetermined amplitude by multiplying the
30 obtained data value of the difference with a positive constant
value A for giving a predetermined amplitude;

an adder portion for obtaining a summed signal
by summing the signal with the predetermined amplitude obtained
from the constant multiplying portion and one of the real part
35 $X_r(k, t)$ and the imaginary part $X_i(k, t)$ of the complex Fourier
coefficients stored temporarily in the second temporary

storage means; and

a basic function arithmetic processing portion for receiving the summed signal obtained from the adder portion and the other of the real part $X_r(k, t)$ and the imaginary part $X_i(k, t)$ of the complex Fourier coefficients stored temporarily in the second temporary storage means and carrying out an arithmetic operation on the received signals using a constant based on a basic frequency thereby to obtain the complex Fourier coefficients $X_r(k, t+1)$ and $X_i(k, t+1)$ at time $t+1$.

2. A recursive discrete Fourier transformation device as claimed in claim 1 wherein the positive constant value A for providing with an amplitude corresponding to a difference between the $x(t+N)$ and the $x(t)$ is capable of being set selectively with 1, square root of N or $1/N$.

3. A recursive discrete Fourier transformation device wherein data values $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1), x(t+N)$ sampled at times $t, t+1, t+2, t+3, \dots, t+N-1, t+N$ (N is a positive integer which is 1 or more) each having an equal interval are supplied and as complex Fourier coefficients under degree k (k is 0 or a positive integer smaller than N) obtained by, with such N data values supplied since time t as a data stream, carrying out complex Fourier transformation on the data stream, a real part $X_r(k, t)$ and an imaginary part $X_i(k, t)$ are obtained, the discrete Fourier transformation device comprising:

a first temporary storage means for storing the data stream $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1)$ supplied since time t at time $t+N-1$ temporarily;

a discrete Fourier operation means for obtaining the complex Fourier coefficients $X_r(k, t)$ and $X_i(k, t)$ of the data stream stored temporarily in the first storage means; and

a second temporary storage means for storing the complex Fourier coefficients $X_r(k, t)$ and $X_i(k, t)$ obtained by the discrete Fourier operation means,

wherein the discrete Fourier operation means obtains complex Fourier coefficients $X_r(k, t)$ and $X_i(k, t)$ according to following equations.

$$X_r(k, t+1) = \left\{ X_r(k, t) + \frac{1}{A} [x(t+N) - x(t)] \right\} \times \cos \left[2 \frac{\pi k}{N} \right] + X_i(k, t) \sin \left[2 \frac{\pi k}{N} \right]$$

5 $X_i(k, t+1) = X_i(k, t) \cos \left[2 \frac{\pi k}{N} \right] - \left\{ X_r(k, t) + \frac{1}{A} [x(t+N) - x(t)] \right\} \sin \left[2 \frac{\pi k}{N} \right]$

where, A is a positive constant value for providing $[x(t+N) - x(t)]$ with an amplitude.

10 4. A recursive discrete Fourier transformation device as claimed in claim 3 wherein the positive constant value A for providing with an amplitude corresponding to a difference between the $x(t+N)$ and the $x(t)$ is capable of being set selectively with 1, square root of N or $1/N$.

15 5. A recursive discrete Fourier transformation device wherein data values $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1), x(t+N)$ sampled at times $t, t+1, t+2, t+3, \dots, t+N-1, t+N$ (N is a positive integer which is 1 or more) each having an equal interval are supplied and with such N data values supplied
20 since time t as a data stream, complex Fourier transformation is carried out to the data stream using a plurality of degrees k (k is 0 or a positive integer smaller than N) so as to obtain real parts $X_r(k, t)$ and imaginary parts $X_i(k, t)$ as plural sets of complex Fourier coefficients, the discrete Fourier
25 transformation device comprising:

a first temporary storage means for storing the data stream $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1)$ supplied since time t at time $t+N-1$ temporarily;

30 plural discrete Fourier operation means for obtaining the complex Fourier coefficients $X_r(k, t)$ and $X_i(k, t)$ for the data stream stored temporarily in the first storage means

for each of plural k values; and

a second temporary storage means for storing each set of the complex Fourier coefficients $X_r(k, t)$ and $X_i(k, t)$ obtained by the plural discrete Fourier operation means
5 corresponding to each k value,

the discrete Fourier operation means including:

a subtracting portion for obtaining a data value of a difference between a data value $x(t+N)$ supplied at time $t+N$ and a data value $x(t)$ memorized temporarily in the first
10 storage means;

a constant multiplying portion for obtaining a signal with a predetermined amplitude by multiplying the data value of the difference obtained by the subtracting portion with a positive constant value A for giving a predetermined
15 amplitude;

an adder portion for obtaining a summed signal by summing the signal with the predetermined amplitude obtained from the constant multiplying portion and one of a real part $X_r(k, t)$ and an imaginary part (k, t) of the complex Fourier
20 coefficients stored temporarily by the second temporary storage means; and

a basic function arithmetic processing portion for receiving the summed signal obtained from the adder portion and the other of the real part $X_r(k, t)$ and the imaginary part
25 (k, t) of the complex Fourier coefficients stored temporarily in the second temporary storage means and carrying out an arithmetic operation on the received signals using a constant based on a basic frequency thereby to obtain complex Fourier coefficients $X_r(k, t+1)$ and $X_i(k, t+1)$ at time $t+1$.
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6. A recursive discrete Fourier transformation device as claimed in claim 5 wherein the quantity of the degrees k is N .

35 7. A recursive discrete Fourier transformation device as claimed in claim 5 wherein the positive constant value A

for providing with an amplitude corresponding to a difference between the $x(t+N)$ and the $x(t)$ is capable of being set selectively with 1, square root of N or $1/N$.

5 8. A recursive discrete Fourier transformation device
wherein data values $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1),$
 $x(t+N)$ sampled at times $t, t+1, t+2, t+3, \dots, t+N-1, t+N$ (N
is a positive integer which is 1 or more) each having an equal
interval are supplied and with such N data values supplied
10 since time t as a data stream, complex Fourier transformation
is carried out to the data stream using a plurality of degrees
 k (k is 0 or a positive integer smaller than N) so as to obtain
real parts $X_r(k, t)$ and imaginary parts $X_i(k, t)$ as plural
sets of complex Fourier coefficients, the discrete Fourier
15 transformation device comprising:

 a first temporary storage means for storing the data
stream $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1)$ supplied
since time t at time $t+N-1$ temporarily;

 plural discrete Fourier operation means for obtaining
20 the complex Fourier coefficients $X_r(k, t)$ and $X_i(k, t)$ for
the data stream stored temporarily in the first storage means
for each of plural k values; and

 a second temporary storage means for storing each set
of complex Fourier coefficients $X_r(k, t)$ and $X_i(k, t)$ obtained
25 by the plural discrete Fourier operation means corresponding
to each k value,

 the discrete Fourier operation means including:

 a common subtracting portion for obtaining a data
value of a difference between a data value $x(t+N)$ supplied
30 at time $t+N$ and a data value $x(t)$ memorized temporarily in
the first storage means;

 a common constant multiplying portion for
obtaining a signal with a predetermined amplitude by
multiplying the data value of the difference obtained by the
common subtracting portion with a positive constant value A
35 for giving a predetermined amplitude;

an adder portion for obtaining a summed signal by summing the signal with the predetermined amplitude obtained from the common constant multiplying portion and one of a real part $X_r(k, t)$ and an imaginary part $X_i(k, t)$ of the complex Fourier coefficients stored temporarily in the second temporary storage means; and

a basic function arithmetic processing portion for receiving the summed signal obtained from the adder portion and the other of the real part $X_r(k, t)$ and the imaginary part $X_i(k, t)$ of the complex Fourier coefficients stored temporarily in the second temporary storage means and carrying out an arithmetic operation on the received signals using a constant based on a basic frequency thereby to obtain the complex Fourier coefficients $X_r(k, t+1)$ and $X_i(k, t+1)$ at time $t+1$.

9. A recursive discrete Fourier transformation device as claimed in claim 8 wherein the quantity of the degrees k is N .

10. A recursive discrete Fourier transformation device as claimed in claim 8 wherein the positive constant value A for providing with an amplitude corresponding to a difference between the $x(t+N)$ and the $x(t)$ is capable of being set selectively with 1, square root of N or $1/N$.

11. A recursive discrete Fourier transformation device wherein data values $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1), x(t+N)$ sampled at times $t, t+1, t+2, t+3, \dots, t+N-1, t+N$ (N is a positive integer which is 1 or more) each having an equal interval are supplied and as a complex Fourier coefficient under degree k (k is 0 or a positive integer smaller than N) obtained by, with such N data values supplied since time t as a data stream, carrying out complex Fourier transformation on the data stream, a real part $X_r(k, t)$ and an imaginary part $X_i(k, t)$ are obtained, the discrete Fourier transformation device comprising:

a data updating means for obtaining a first subtraction signal by subtracting data $x(t)$ supplied before N sampling period from data $x(t+N)$ supplied at time $t+N$;

5 a recursive processing means for obtaining a new second subtraction signal by subtracting an addition signal generated recursively using an already generated second subtraction signal from the obtained first subtraction signal; and

10 a multiplying means for obtaining the real part $X_r(k, t)$ of the Fourier coefficients by summing up a signal obtained by multiplying the new second subtraction signal obtained by the recursive processing means with a first constant value and a signal obtained by multiplying the second subtraction signal supplied before a sampling period with a second constant value and for obtaining the imaginary part $X_i(k, t)$ of the
15 Fourier coefficients by multiplying the new second subtraction signal with a third constant value,

wherein the addition signal generated recursively by the recursive processing means is a signal obtained by summing up a signal obtained by multiplying the second subtraction signal obtained before a sampling period with a fourth constant value and the second subtraction signal obtained before two
20 sampling periods.

12. A recursive discrete Fourier transformation device
25 wherein data values $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1), x(t+N)$ sampled at times $t, t+1, t+2, t+3, \dots, t+N-1, t+N$ (N is a positive integer which is 1 or more) each having an equal interval are supplied and as a complex Fourier coefficient under degree k (k is 0 or a positive integer smaller than N) obtained by, with such N data values supplied since time t
30 as a data stream, carrying out complex Fourier transformation on the data stream, a real part $X_r(k, t)$ and an imaginary part $X_i(k, t)$ are obtained, the discrete Fourier transformation device comprising:

35 a data updating means for obtaining a first subtraction signal by subtracting data $x(t)$ supplied before N sampling

period from data $x(t+N)$ supplied at time $t+N$;

a recursive processing means for obtaining a new second subtraction signal by subtracting an addition signal generated recursively using an already generated second subtraction
5 signal from the obtained first subtraction signal; and

a multiplying means for obtaining the real part $X_r(k, t)$ of the Fourier coefficients by summing up a signal obtained by multiplying the new second subtraction signal obtained by the recursive processing means with a first constant value
10 and a signal obtained by multiplying the second subtraction signal supplied before a sampling period with the second constant and for obtaining the imaginary part $X_i(k, t)$ of the Fourier coefficients by multiplying the new second subtraction signal with a third constant value,

15 wherein a transfer function $H(Z)$ for the data updating means, the recursive processing means and the multiplying means connected as subsidiary components is given according to a following equation.

$$H(z) = A(1 - z^{-N}) \left\{ \frac{\cos \left[2 \frac{\pi k}{N} \right] - j \sin \left[2 \frac{\pi k}{N} \right] - z^{-1}}{1 - 2 \cos \left[2 \frac{\pi k}{N} \right] z^{-1} + z^{-2}} \right\}$$

20 where A is a positive constant value for providing $[x(t+N) - x(t)]$ with an amplitude.

13. A recursive discrete Fourier transformation device as claimed in claim 12 wherein the positive constant value
25 A for providing with an amplitude corresponding to a difference between the $x(t+N)$ and the $x(t)$ is capable of being set selectively with 1, an inverse number of square root of N or $1/N$.

30 14. A recursive discrete Fourier transformation device wherein data values $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1)$,

$x(t+N)$ sampled at times $t, t+1, t+2, t+3, \dots, t+N-1, t+N$ (N is a positive integer which is 1 or more) each having an equal interval are supplied and with such N data values supplied since time t as a data stream, complex Fourier transformation is carried out to the data stream using a plurality of degrees k (k is 0 or a positive integer smaller than N) so as to obtain real parts $X_r(k, t)$ and imaginary parts $X_i(k, t)$ as plural sets of complex Fourier coefficients, the discrete Fourier transformation device comprising:

plural data updating means corresponding to the plurality of degrees k , for obtaining a first subtraction signal by subtracting data $x(t)$ supplied before N sampling period from data $x(t+N)$ supplied at time $t+N$;

plural recursive processing means corresponding to the plurality of degrees k , for obtaining a new second subtraction signal by subtracting an addition signal generated recursively using an already generated second subtraction signal from the obtained first subtraction signal; and

plural multiplying means corresponding to the plurality of degrees k , for obtaining a real part $X_r(k, t)$ of the Fourier coefficients by summing up a signal obtained by multiplying the new second subtraction signal obtained by the recursive processing means with a first constant value and a signal obtained by multiplying the second subtraction signal supplied before a sampling period with the second constant and for obtaining an imaginary part $X_i(k, t)$ of the Fourier coefficients by multiplying the new second subtraction signal with a third constant value,

wherein the addition signal generated recursively by each of the plural recursive processing means is a signal obtained by summing up a signal obtained by multiplying the second subtraction signal obtained before a sampling period with a fourth constant value corresponding to each degree k , and the second subtraction signal obtained before two sampling periods.

15. A recursive discrete Fourier transformation device as claimed in claim 14 wherein the quantity of the degrees k is N .

5 16. A recursive discrete Fourier transformation device whereindatavalues $x(t), x(t+1), x(t+2), x(t+3), \dots, x(t+N-1), x(t+N)$ sampled at times $t, t+1, t+2, t+3, \dots, t+N-1, t+N$ (N is a positive integer which is 1 or more) each having an equal interval are supplied, data $x(t)$ supplied before N sampling
10 period is subtracted from data $x(t+N)$ supplied at time $t+N$ so as to obtain a first subtraction signal, and with such N data values supplied since time t as a data stream based on the obtained first subtraction signal, a complex Fourier transformation is carried out to the data stream using a
15 plurality of degrees k (k is 0 or a positive integer smaller than N) so as to obtain real parts $X_r(k, t)$ and imaginary parts $X_i(k, t)$ as plural sets of complex Fourier coefficients, the discrete Fourier transformation device comprising:

20 plural recursive processing means corresponding to the plurality of degrees k , for obtaining a new second subtraction signal by subtracting an addition signal generated recursively using an already generated second subtraction signal from the obtained first subtraction signal; and

25 plural multiplying means corresponding to the plurality of degrees k , for obtaining a real part $X_r(k, t)$ of the Fourier coefficients by summing up a signal obtained by multiplying the new second subtraction signal obtained by the recursive processing means with a first constant value and a signal obtained by multiplying the second subtraction signal supplied
30 before a sampling period with the second constant and for obtaining an imaginary part $X_i(k, t)$ of the Fourier coefficients by multiplying the new second subtraction signal with a third constant value,

35 wherein the addition signal generated recursively by each of the plural recursive processing means is a signal obtained by summing up a signal obtained by multiplying the

second subtraction signal obtained before a sampling period with a fourth constant value corresponding to each degree k , and the second subtraction signal obtained before two sampling periods.

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17. A recursive discrete Fourier transformation device as claimed in claim 16 wherein the quantity of the degrees k is N .